Exploring AI Alternatives in Support of the General Observer Program for NGST

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Abstract

One of the manually intensive efforts of the Hubble Space Telescope (HST) operations is the specification and validation of the detailed proposals submitted by scientists observing with HST. In order to meet the operational cost targets for the Next Generation Space Telescope (NGST), this process needs to be dramatically less time consuming and less costly. We are involved in evaluating this process and prototyping how artificial intelligence and user interface advances can be applied to reduce the time and effort involved for both scientists and the telescope operations staff. This paper describes the problem area more fully and reports on the current status and direction of the prototyping project.

Summary of Proposal Process with HST

HST uses a two-phase proposal process. In the first phase, scientists provide a description and scientific justification for the proposed observations along with preliminary information about targets and exposures. Phase I proposals are collected in an annual cycle. A peer review process reviews the submitted Phase I proposals and accepts proposals based on available time and scientific merit.

Once a Phase I proposal has been accepted the scientists must fill out a more detailed Phase II proposal that specifies the targets, instrument modes and exposure times in sufficient detail to allow HST's operations systems to schedule and execute the observations.

There are several tools that support the Phase II process. Many are available publicly, including the Remote Proposal Submission software (RPS2), an X-Windows based graphical user interface developed by the Space Telescope Science Institute (ST ScI) staff, as well as web-based reference manuals, and exposure calculators. Additional tools are available to the ST ScI staff.

NGST will be a fundamentally simpler observatory than HST. It will fewer instruments, the instruments will be simpler, and its location in space will provide fewer viewer constraints. These factors will help reduce the complexity of specifying of detailed observing proposals.

However, even greater gains in efficiency are needed in order to meet the operational cost targets for the Next Generation Space Telescope (NGST). The labor and costs involved in managing the general observer program still need to be lowered substantially.

Objectives of the Prototyping Phase

Our main objectives for development of the Scientist's Expert Assistant (SEA) are:

a) The system should be *intelligent.* It should employ artificial intelligence methodologies and paradigms to assist and guide the scientist in producing a proposal that is flight ready.

b) The system should be highly *intuitive*. The user interface should not require extensive training, scientists should be able to work with SEA with little or no assistance.

c) The system should be *distributed.* It should allow delivery and processing of proposals via the World Wide Web across a wide range of computing systems.

d) The system should be *adaptable*. As the telescope staff learns how best to use NGST once it is launched and operational, the system should be able to learn from that experience to further improve its effectiveness.

e) The system should be easily *integrated* with other NGST planning and operations modules.

f) The system should be *flexible*. Since NGST is not scheduled for launch until about 2007, the system development must allow for changes in technology. Further, much of the process of developing observing proposals is common among observing platforms. This system could and should be an effective alternative for other observatories, both present and future.

We are currently looking at the overall process and how it can be better supported through automated means both in a general sense and in areas specific to NGST. Thus far, we believe the following will result in substantial improvements:

- Utilize expert assistant technology to conduct an on-line, guided interview with the general observer in order to solicit science requirements in "science language" and translate and package these requirements into a flight-ready proposal. The "interview" should accommodate a range of user types, from "novice" to "expert", and the system should be able to hide the minute details of the observatory from its user.

- Define and create an object-oriented system that provides “generic” support for a two-phase proposal development process. Then, develop framework-specific modules to support NGST, and also other observatories prior to NGST’s launch.

- Utilize newer, more graphical and dynamic user interface techniques to make the process more intuitive.

- Better integrate reference material, providing an intelligent context-sensitive means to helping scientists find relevant technical reference material quickly and easily.

- Better integrate the various computational tools - for example, once the instrument mode and targets have been selected, the scientist should not have to go to a separate exposure calculator tool, re-enter that information to obtain exposure times, and manually enter those exposure times back into the proposal.

- Standardize the interface for the computational tools across the different instruments in order to decrease the learning curve and increase efficiency.

The current plan is for the SEA to be explored first through two prototyping and “proof-of-concept” phases to evaluate how well the goals can be met. If successful, the next step is to build the operational SEA for an instrument on an operational observatory in order to develop operational experience with the SEA. This will ensure that by the time the instruments for NGST are well defined, the SEA will be a proven platform that simply needs adapting to the NGST specific instruments.

Goddard’s Advance Architectures and Automations Branch is working with the STScI to explore SEA alternatives with the goal of using the Advanced Camera for Surveys (ACS) instrument (scheduled to be installed in HST in 1999) as our operational test-bed.

Progress to Date

Thus far, the team has focused on gaining an overview of the proposal process and defining the scope and schedule for the prototype effort. We have reviewed the overall Phase II process and the areas within in that are currently manually intensive. We have also begun developing the rules for prototyping an instrument configuration module for ACS. Finally, we are investigating similar development efforts for other observing platforms to see if we can leverage their work.

In the process of our analysis, we feel that there are five priority areas for development. These modules will initially be developed separately, but we expect that the tools will be integrated into a single iterative user-interface:

Graphical, “real-time” exposure calculator

This initial tool will generate real-time interactive graphs showing Signal-Noise Ratio and Source counts across a range of exposure times and wavelengths. The tool will allow the scientist to edit target or instrument parameters and instantly see their effect. We are targeting a Beta release for ACS by the end of December 1997. This tool is being developed in Java and will be a fairly simple application that should be able to replace the need to browse through over 100 pages of graphs and tables typically found in the HST Instrument Manuals. The development of this tool will also provide an initial development platform for the user-interface guidelines and underlying data objects that will be used for subsequent tools. We expect that in the first phase, this tool will not use expert system technology.

“Visual” Target Tuner (VTT)

The VTT is a graphical tool for fine tuning target coordinates and orientation. Currently, observers must independently research target information and manually enter the information into their proposal. If they have a need to include or exclude specific objects, they must manually determine a specific orientation for the instrument. Giving a precise orientation requirement significantly hampers the schedulability of their program. The VTT will know, however, the areas that need to be included or excluded and can therefore pass on to the scheduling system and range of acceptable orientations. Further, there are currently no visual tools to help predict the overlap of spectroscopic slits, or the impact of refraction spikes.

The VTT seeks to be that visual environment. We are planning to prototype the VTT in several phases. The first phase (targeted for mid-1998) will be limited to displaying a previous FITS image, allowing the user to specify inclusion or exclusion areas, and fine tune the specific location. In the second phase (targeted for late-1998) we will add the ability to model defraction spikes and spectroscopic slits. In both phases, we anticipate that this tool will be primarily a visual and graphical aid.

Instrument Configuration Expert System (ICES)

This module will be a rule-based expert system that will guide the observer through the definition of instrument parameters by asking a series of science-based questions, and then providing recommended settings for the instrument based on the answers received. The goal will be to eliminate the need for the observer to study and absorb the range of technical details about the workings of an instrument, and instead let them focus on the science they want to achieve. This tool will also be developed in several phases. The first phase will have a fairly small rule-system that will focus on filter selection, and will emphasize the development of a good user-interface system and standards.

The user-interface for this expert system has some relatively unique needs. It needs to be able to integrate with the other tools and therefore have a compatible look and feel. It needs to be able to ask and save responses to questions in a manner that will be acceptable to both advanced and novice users. It needs to transparently interact with both the user on the "front-end" and a rules-engine on the "back-end". It also must support intelligent cross-references to technical literature, since while we are trying to allow observers to bypass up-front study of the technical instrument parameters, we are *not* trying to prevent them from studying the technical details. We want to help them focus quickly on the areas that are most relevant to their science objectives.

The second phase of the ICES will concentrate on expanding the rules and capabilities of the system. This is a critical objective for the SEA. We are striving to discover if the tool can contain a sufficient level of science expertise to free the observers from the technical details of the instrument and significantly reduce the support needed from Institute experts. We also must find out once such a system is achieved, if can we gain the acceptance from the observing community.

Visit Planner Expert System (VPES)

Thus far the modules described will primarily focus on defining a single exposure, both target parameters through the VTT and instrument parameters through the ICES. The Visit Planner Expert System will work to provide assistance in laying out multi-exposure "visits". Both observing scientists and Institute staff currently spend a great deal of time planning multi-exposure visits. These challenges include:

- Laying out multiple exposures to create a mosaic
- Imaging a single target with a variety of instrument configurations.
- Planning not just the individual exposure times, but also the overhead time necessary to perform other tasks such as slewing the telescope, and reading the CCD buffers after an exposure.

These are currently manual, iterative processes that involved balancing exposure times to achieve the desired science objectives while keeping within the overall visit time constraints. The VPES will be an expert system that will query the observer with a series of questions about their science objectives and priorities. It will be able to recommend an optimal trade-off between individual exposure times and total visit execution time.

Re-validation Agent

This module has not yet been fully analyzed. Currently, the Program Coordinators at the Institute spend a great deal of time re-processing already approved, but still pending proposals when a change to the instrument occurs. These changes can include a variety of things, for example, new calibration information that affects optimal exposure times. This concept for the re-validation agent is to use agent-based technology to evaluate the impact of changes to both submitted proposals and proposals that are still under development. The agent could seek out impacted proposals, calculate the effect of the impact, develop a recommendation and then notify the observer and Institute staff of possible alternatives.

Issues and Challenges

We have several challenges to overcome in developing this prototype. This section will highlight a few of those.

The first challenge is to gain synergy with other development efforts. We recognize that we are not the only group interested in improving resources for observers. The Gemini group is developing a new system, as is the Very Large Telescope (VLT) group. We need to stay in touch with these efforts and develop synergy where possible to minimize development costs and maximize product quality.

Second, we want the system to be applicable to other observing platforms. While space-based astronomy has a significant set of unique issues and parameters, the fundamental process of defining an observing proposal is not particularly unique between observing platforms. We are striving to develop a system that will be easily adaptable to different instruments, different target types, and to different base observatories.

Third, we are faced with rapidly changing and evolving technology. While this prototyping effort will use a "near-term" instrument, ACS as the testbed, the long-term objectives are cost-effective systems for NGST, a system that is not scheduled to launch for almost ten years. The technological changes over the last ten years make it likely that not only will the basic technology we use today be obsolete, but the whole approach system may have been replaced by a system that is not yet even in the conceptual thinking of most developers. Consequently, we are involved in a trade-off between developing with proven established methods and emerging technologies and approaches. Our currently target environment is Internet-based and platform-independent. We are using object-oriented design with Java as the development language. We are balancing between the expectation that computing and network speeds will continue to dramatically improve and working with the existing limitations.

Finally, we are striving to achieve a balance between solving problems that may be unique to HST (both its hardware and its orbital constraints) while conceiving of what different constraints there may be for NGST.

Conclusion

We have sent representatives to this Workshop on Planning and Scheduling for a variety of reasons. We want to share our research to date. We want to seek out additional input on approaches and methodologies. We are interested in generating interest in our project. And we are looking for ways in which our work might provide a basis to help other observing platforms reduce the costs of their proposing systems.